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Name of the file: Scope of the patent application

Application Item 1:

Graphite compound material that has a No. 1 sheet, and on both sides of the No. 1 sheet, there are laminated No. 2 and No. 3 sheets made of either metal or ceramic, and the exposed ends of the No. 1 sheet are closed.

Application Item 2:

Graphite compound material described in Application Item No. 1, in which the previously-mentioned No. 2 and No.3 sheets are extruded from the previously-mentioned No. 1 sheet, and by pressing this extruded parts, the exposed ends of the No. 1 sheet are closed.

Application Item 3:

Graphite compound material described in the Application Items No. 2 and 3, that is made of isotropic heat conducting material which has larger specific heat capacity than the previously-mentioned graphite sheet.

Application Item 4:

Graphite compound material described in Application Item 1 or 3 in which the previously-mentioned No.1 sheet is 0.3-10mm thick (before pressurizing), and the previously-mentioned No. 2 & 3 sheets each have 0.02-20mm thickness (before pressurizing).

Application Item 5:

Graphite compound material described in Application Item 1 or 4 in which the previously-mentioned No.1 sheet has heat conductivity of over 100W/m·K in the surface direction before pressurizing.

Application Item 6:

Graphite compound material described in the Application Item 1 or 5 in which the previously-mentioned No.2 and 3 sheet has heat conductivity of over 60W/m·K, and the specific heat capacity is more than double that of sheet No. 1.

Name of the file: Details

Name of the Invention: Graphite compound material

Technological field

0001:

This invention concerns a graphite compound material which is used for cooling systems and radiating systems, etc. of electronic devices.

Background technology:

0002:

Electronic devices such as notebook personal computers, PDAs (Personal Digital Assistants), cell phones, digital cameras, digital videos etc. have rapidly accelerating speed of function and processing capability. Consequently, the heat generated by semiconductor elements and other electronic parts that are used for the CPU, etc. are increasing. Therefore, effective cooling and radiating systems are required in order to have motion characteristics and reliability of semiconductor elements.

0003:

In electronic devices that have high heat semiconductor elements, there are various types of cooling and radiating systems. Typical of those are cooling by attaching a cooling fan, cooling fin, Peltier element (cooling element), etc. to the electronic device itself, or exhausting heat inside the device by attaching an exhaust fan to the device itself. However, for portable electronic devices, it is difficult to attach a cooling fan or fin to the device itself because of the small space. Also a semiconductor element cannot be cooled effectively by only an exhaust fan, using the heat generated inside the electronic device body.

0004:

Therefore, materials which tend to get hot, such as semiconductor elements, etc. inside the electronic device are connected to an exhaust device such as exhaust fan or fin attached outside the wall of the electronic device, using a heat conducting material such as heating pipe in order to save space for the heating system, and increase the effectiveness of cooling the semiconductor element. This method is already is used partially (for instance, see Tokkyo reference 1, 2). Moreover, use of graphite sheet or compound sheet in which an aluminum or metal sheet such as copper is laminated onto both surfaces of the graphite sheet 1, is considered as shown on Drawing 9 (refer to Tokkyo reference 2, 3.).

0005:

By the way, since heat pipe is not only heavy but also it has difficulty because of bending shape; for that reason, it is difficult to install inside a portable electronic device. On the other hand, graphite sheet is an excellent heat conducting material, because its heat dispersion characteristic is good, light in weight, space limitation is small; it disperses the heat quickly generated by portable electronic devices that are getting smaller and smaller. Especially, the graphite compound sheet is getting more attention, because it is easy and practical to handle and supported by the metal sheet.

0006:

However, graphite is essentially a weak material in that graphite powder falls from its ends to cause electrical shorts inside the electronic devices. Especially, recently, highly dense minute wiring inside the electronic devices are progressing, therefore if only a few 10μm particles, which are a very small amount, drop, it causes short circuit to become a big problem.

(Tokkyo reference) Tokkai-Hei8-204373 Open Journal

(Tokkyo reference) Tokkai2000-82888 Open Journal

(Tokkyo reference) Tokkai2003-188323 Open Journal

Opening of the invention:

Problem this invention is trying to solve:

0007:

This invention was done in order to solve this kind of problem: the purpose is to offer a graphite compound material that can prevent fall of graphite powder from the ends, as the graphite compound material with metal sheets are laminated on both surfaces.

Procedure to solve the problem

0008:

The graphite compound material mentioned in Application Item No.1 of this invention is a compound that in which on both sides of the No. 1 sheet made of graphite, No. 2 and No. 3

sheets are laminated, and the previously-mentioned ends of the sheet are closed off, in order to achieve the previously-mentioned purpose.

0009:

The invention described in Application Item No. 2 is, graphite compound material of the Application Item No.1, with the previously-mentioned No. 2 and No. 3 sheets extended longer than previously-mentioned No.1 sheet, and by pressing these extended parts together, the exposed part of the No. 1 sheet is closed off.

0010:

The invention described in Application Item No.3, has the characteristics that in the graphite compound material in Application Item No. 1 or 2, the previously-mentioned No. 2 and No. 3 sheets are made of an isotropic material with larger specific heat capacity than that of the previously-mentioned graphite sheet.

0011:

The invention described in the Application Item No.4 has following characteristics: in the graphite compound mentioned in either of the Application Items No. 1 or 3, the previously-mentioned No. 1 sheet has 0.03-10mm thickness (before compression), and the previously-mentioned No. 2 or 3 sheet each has 0.02-20mm thickness (before compression).

0012:

The invention described in the Application Item No.5 has following characteristics: in the graphite compound mentioned in either the Application Item No. 1 or No. 4, the previously-mentioned No. 1 sheet has over 100W/m·k heat conductivity before compression.

0013:

The invention described in the Application Item No.6 has following characteristics: in the graphite compound mentioned in either the Application Item No. 1 or No. 5, the previously-mentioned No.2 or No. 3 sheet has over 60W/m·k heat conductivity, and the specific heat capacity is twice large that of the No.1 sheet.

0014:

For the graphite compound of this invention, powder from exposed ends can be prevented, for instance, even if it is used for electronic devices, it can be reliable because there is no concern for short circuit.

0015:

The actual form of this invention will be explained showing drawings from now on.

0016:

Drawing 1 is a cross section of the overall view of one of the actual forms of the graphite compound of this invention. In Drawing No. 1, graphite compound material 101 of this actual form is ideal as heat conducting material, for instance, a heat conducting body for heating and cooling of an electronic device: it is made of sheet 11 made of graphite with high heat conductivity in the surface direction, and on both sides of this graphite sheet 11, there are two sheets 12, 12 which are made of either metal or ceramic with isotropic heat conductivity, and they are made in larger size than graphite sheet 11. Both sheets 12, 12 are protruded outwardly, and by compressing these protruded parts 12 together, both sheets 11 and 12 become one sheet, which is formed so that the exposed ends of the graphite sheet 11 are closed off. Also at the same time, when the protruded part 12a is compressed, the two sheets 12, 12 are also compressed onto the main surface of the graphite sheet 11; the heat conductivity and heat dispersion properties of the graphite sheet 11 are increased by this compression, consequently the heat conductivity and heat dispersion properties of the graphite compound material 101 are increased.

0017:

The graphite sheet 11 has layer type construction in that the graphite crystals are all laminated in line with the surface direction; because of this kind of construction, it has high conductivity such as over 100W/m·K or even 200W/m·K. The thickness of the graphite sheet 11 (before compression) is not particularly limited, but when it is used as a heat conduction body to cool a heating body of an electric device, about 0.03-10mm is preferred, and about 0.25-2mm is even better.

0018:

This type of graphite sheet can be made, for instance by a compressing mold with roller or a compressing a mold of graphite flakes, or extruding a mold of graphite flakes, or compressing mold or extruding mold of graphite flakes as heated amorphous gas is added. Also it can be made by heat treatment of (the graphite flakes) in an inert gas atmosphere made by heating, for instance aromatic poly-imide [?] film, to several thousand degrees temperature.

0019:

For the sheet material 12 that can be laminated onto this kind of graphite sheet 11, one which has over 60W/mK heat conductivity, and it also preferred to have over twice larger specific heat capacity of that of the graphite sheet 21. In reality, a metal sheet such as Aluminum or Copper, or a high heat conducting ceramic sheet, for instance Aluminum Nitride (A1N), Silicon Carbide (S i C), Alumina (Al_2O_3), Boric Acid Nitride (BN), Silicon Nitride (SiN), or Zircon (ZrO_2) etc. can be used.

0020:

The thickness of this type of sheet made of metal or ceramics is preferably 0.02-20mm (before compression) for each sheet, and 0.02-1mm is better.

0021:

The graphite compound of this actual form can be manufactured, for instance as shown in Drawing 2 ; first paste the glue 13 on both surfaces of the graphic sheet 11 and one side of either metal or ceramic sheet 12 to laminate them in such a way that glue side (of sheet 12 & 13) is in tact with the graphite sheet 11; then put this laminated body on the compression board 14, and press it with a roller in the heating direction. As for the material of glue 24, cellulose type, acryl type, epoxy type, silicone type, or urethane type poly-vinyl-alcohol (popaaru?), etc. glue can be used. Or, without using such glue, graphite 11 and metal or ceramics sheet can be compressed to laminate into one sheet with a material that has melting characteristic between the sheets.

0022:

For the graphite compound material 101 in this actual form, (when it is used in) electronic devices, heat generated from heating body can be conducted more effectively to the radiating system, because the heat conducting property of the graphite sheet 11 is increased greatly, by laminating sheet 12 that is made of isotropic heat conducting material and has larger specific heat capacity than sheet 11, onto the main surfaces of graphite sheet 11 which is light and has high heat conductivity in the surface direction.

0023:

And, in this actual form, falling of graphite powder is prevented, since the ends of the graphite sheet are closed. Therefore, when it is used in an electronic device, high reliability is maintained without any problem of short circuit.

0024:
Although the previously-mentioned actual form, part of the graphite sheet 12 which are bent and laminated to the main surface (upper side in the drawing) of the graphite sheet 11 in order to close the ends; but in case of the graphite compound 102 as Drawing 3 shows, two sheets 12 are both bent and connected at about the center of the graphite sheet 11. However, in this instance, it is necessary to use a highly accurate metal mold in the manufacturing process; from the point of actual manufacturing, or simplicity reason, a procedure to bend only one end of the sheet, as shown in Drawing 1, is preferable.

0025:
Not only that, a crack may occur at the bent spot in the previous procedure, because ceramic has smaller elasticity than metal. For that reason, when one of the two sheets 12 that are laminated to graphite sheet 11 is ceramic, it is preferable to take the construction shown in Drawing 1, and not to bend; when both of the sheets 12 are made of ceramics, it has better to use the following procedure. Doing chamfering to the edge (bent part) of the graphite sheet 11 is an effective measure against cracking of the bent part of the sheet 12 also. When the sheet 12 is made of metal, in order to control the crack at the bending part, it is better to chamfer at the edge of graphite sheet 11. If metal sheet is used as the material for the sheet 12, it (chamfering) is especially effective.
0026:
Drawings 4 & 5 each are cross sections of the actual form of another graphite compound material of this invention; the same signs used in Drawing No.1 will be used again, and the same explanation as for Drawing No. 1 will be omitted.
0027:
The graphite compound material 103 shown on Drawing No. 4 has the same actual form as in Drawing No.1 as far as the fact that sheet 12 made of either metal or ceramic is laminated to both main surfaces of the graphite sheet 11, and both ends of sheet 12 are extended further out from the graphic sheet 11. However, in the actual form in Drawing No. 1, the protruded parts 12a from the sheet 12, that are protruded outwardly from graphite sheet 11, are compressed together; but in this actual form, sealing material 15 such as conductive paste, conductive resin, solder etc. is used for the sealing.
0028:
The graphite compound material 104 shown on Drawing No. 5 has the same actual form as in Drawing No. 1, except two metal or ceramic sheets, sheet 12 do not protrude beyond the end of the graphite sheet 11, but conducting laminating tape 16 covers the end of the laminated body.
0029:
In the case of each graphite compound material 103 or 104, just like at the previously-mentioned actual form, the fall of graphite powder is prevented, since the ends of the graphite sheet are closed. Therefore, when it is used in electronic device, high reliability is maintained without the problem of short circuit.
0030:
However, the graphite compound material 103 as shown in Drawing 4, reliability is not quite satisfactory, and for the graphite compound material 104 as shown in the Drawing 5, there is some difference in level due to the thickness of the laminating tape 16 around (the graphite

compound material 104); therefore it is difficult to attach it to a heating body or radiator board closely and it may spoil the function as a heat conducting material.

0031:

Drawings No. 6-8 show the actual form of the previously-mentioned graphite compound material, when graphite compound material 101 is used.

0032:

In the case of the sample shown in Drawing No. 6, the heating surface of heating body 31 such as a conductor element is connected to the one end of the graphite compound 101, and the heat receiving surface of the heat radiating fin 32 as radiator is connected to the surface at the other end. In the sample shown in Drawing No. 7, one side of the main surface of the graphite compound 101 is connected both to the radiating surface of the heating body 31, and the heat receiving side surface of the radiator system 33 with radiating fan. In the sample shown in Drawing No. 8, the graphite compound material 101 is made in a three-dimensional shape so that heating body 31 and box 34 which functions as a radiator body for the electronic device as well, are connected by heating.

0033:

Next, I will show the Actual Samples of this invention, but this invention is not limited to those samples.

Actual Sample 1

0034

Onto the both main surface of the graphite sheet (specific heat capacity 0.13J/K·g, specific gravity 1.78g/cm^3, surface direction heat conductivity 240W/m·K) that is 1.5mm thick, 60mm wide, and 150mm long, a copper sheet (specific heat capacity 0.38J/K·g, specific gravity 8.96g/cm^3, heat conductivity 390W/m·K) that is 0.05mm thick, 63mm wide, 153mm long, is glued by cellulose in such a way that 1.5mm each of the circumference part of the copper sheet protrudes from the graphite sheet, then it is laminated and compressed.

0035:

Actual Sample 2

Onto the both main surface of the graphite sheet (specific heat capacity 0.13J/K·g, specific gravity 1.78g/cm^3, surface direction heat conductivity 240W/m·K) that is 1.45mm thick, 60mm wide, and 150mm long, an aluminum sheet (specific heat capacity 0.27J/K·g, specific gravity 2.24g/cm^3, heat conductivity 220W/m·K) that is 0.1mm thick, 63mm wide, 153mm long, is glued by cellulose in such a way that 1.5mm each of circumference part of the aluminum sheet protrudes from the graphite sheet; then it is laminated and compressed.

0036:

The graphite compound materials made by the previously-mentioned procedures were placed in electronic devices, but fallout of graphite powder could not be found either at the time it was installed or when it was used; consequently, no short circuit occurred. Also it was confirmed that it had an excellent function as heat conductor.

Simple explanation of the Drawings

0037

Drawing No. 1: cross section of the actual form of one of the graphite compounds of this invention.

Drawing No.2: cross section of the sample showing different types of the actual form of the Drawing No. 1.
Drawing No.3: drawing to explain the manufacturing process of the actual form of the Drawing No. 1.
Drawing No. 4: cross section that shows another actual form of the graphite compound material of this invention.
Drawing No.5: cross section that shows yet another actual form of the graphite compound material of this invention.
Drawing No.6: side view that shows a sample of form used in the graphite compound material of this invention.
Drawing No.7: side view that shows another sample of form used in the graphite compound material of this invention.
Drawing No.8: side view that shows yet another sample of form used in the graphite compound material of this invention.
Drawing No.9: slant view that shows a sample of the graphite compound material.
Explanation of the signs
0038:
11. Graphite sheet, 12. Sheet made of either metal of ceramic, 13. Glue, 15. Sealer, 16, Heat conducting laminate tape, 31. Heating body, 32. Heat radiating fin, 33. Radiator, 34. Box, 101-104, Graphite compound material.